

P (2011)

Consequential Steam Generator Tube Rupture (C-SGTR)

What IS C-SGTR?

Consequential Steam Generator Tube Rupture (C-SGTR) events occur when steam generator (SG) tubes leak or fail as a consequence of high differential pressures or high temperatures predicted to occur during certain severe (beyond design basis) accident sequences. The failure of tubes during severe accidents bypasses the containment barrier and can result in adverse offsite radiological release to the environment.

However, it is also possible that the high temperatures accompanying these severe accidents may induce failure in certain locations of the reactor cooling system (RCS) piping system before any SG rupture. In this scenario, failure of the RCS boundary will depressurize and preclude SG tube rupture, thus preventing bypass of the containment barrier.

Motivation

The closure process for the U.S. Nuclear Regulatory Commission's (NRC's) Steam Generator Action Plan in 2009 identified the technical gaps described below that needed further work.

C-SGTR analyses for Westinghouse and Combustion Engineering (CE) plants did not account for updated flaw distributions, consistent modeling of RCS component failure analyses, and impact on large early release frequency (LERF) and offsite consequences.

The additional guidance and tools to support future risk assessments of C-SGTR will assist NRR staff in the evaluation of proposed modifications to existing requirements (e.g., alternate tube repair criteria) and in the assessment of the risk significance of SG tube degradation (in the Reactor Oversight Process).

Objectives

Update computational fluid dynamics (CFD) and system code models for CE plants.

Complete a report on the impact of in-core instrument tube failures on natural circulation for both Westinghouse and CE plants.

Update SG flaw distributions representative of the current population of SGs.

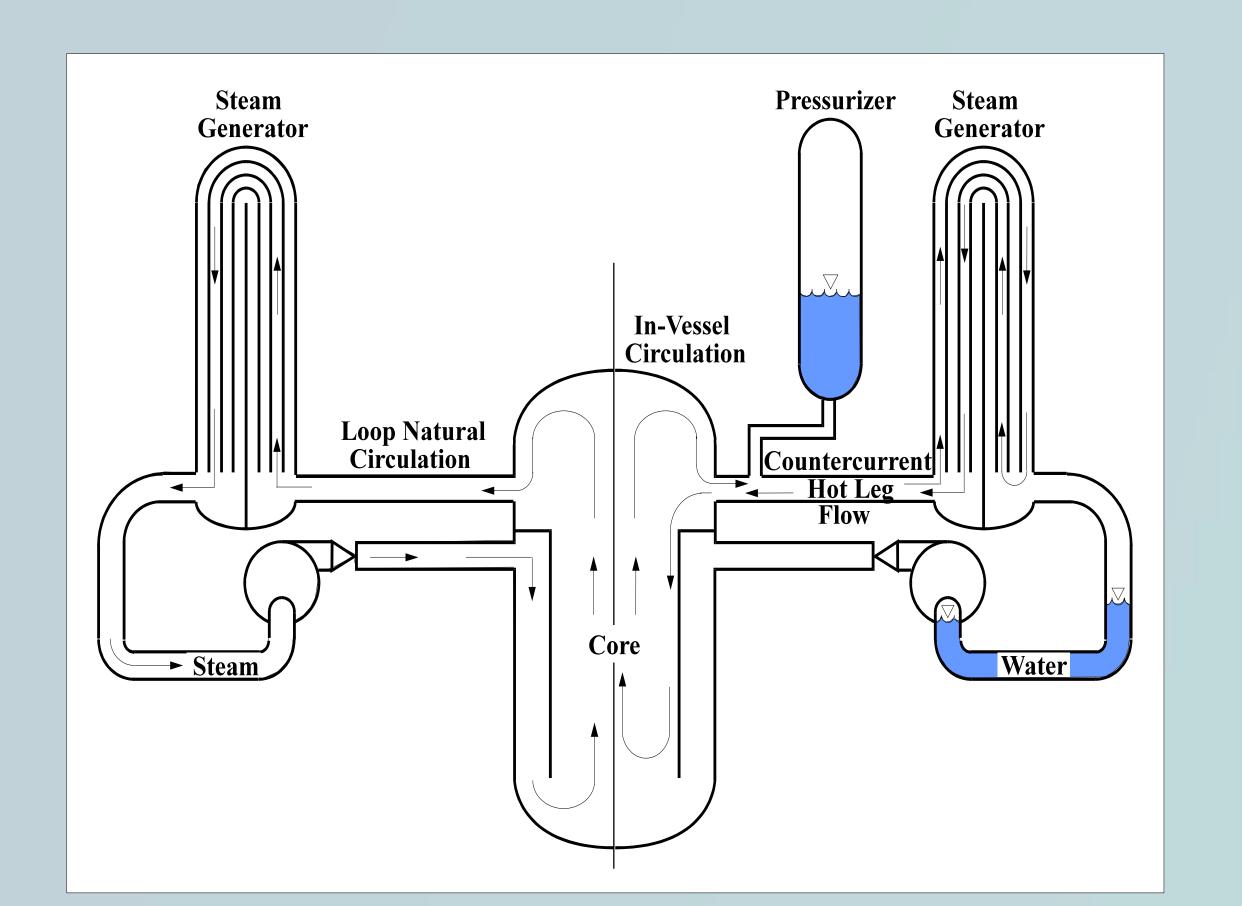
Complete structural analyses of CE and Westinghouse RCS components to establish confidence in the prediction of RCS piping failures.

Develop a user-friendly methodology for assessing the risk associated with consequential tube rupture and leakage in design-basis accident and severe accident events.

Conduct a reassessment of the conditional probabilities of C-SGTR based on updated flaw distributions and updated thermal-hydraulic analyses.

Develop regulatory guidance on risk-informed decision making regarding C-SGTR.

Severe Accident Flow Paths



Station blackout – Reactor Core Pressurizer loses power—natural circulation flow

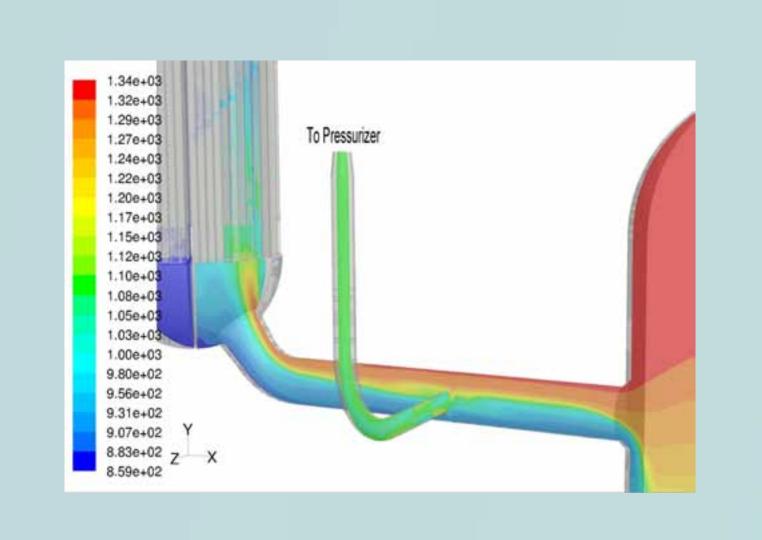
Loop seal preserved—counter current flow in hot leg Secondary side depressurized

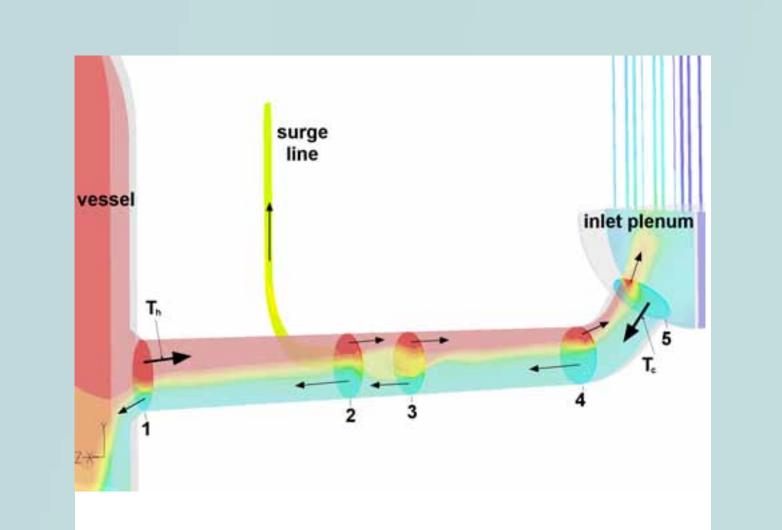
RadioNuclide Input Therr o Hydraulic Input Research R

Computational Fluid Dynamics (CFD)

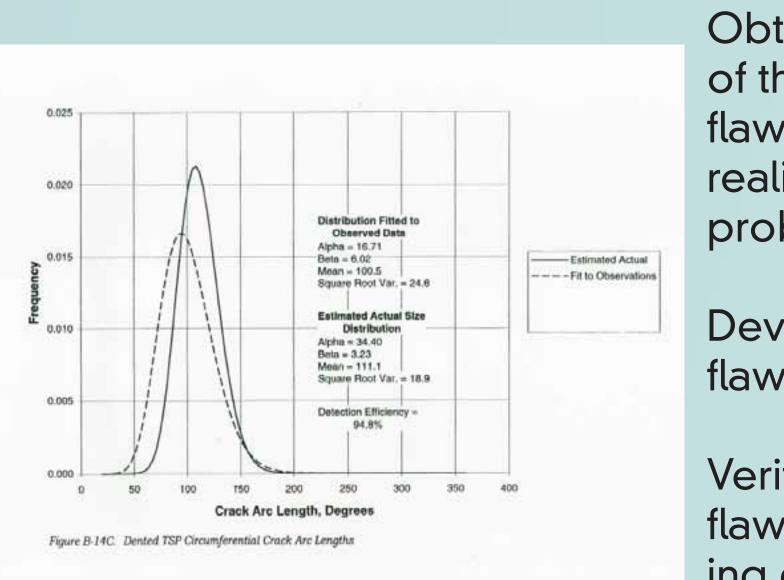
Prediction of—
hot leg and inlet plenum mixing
rates

variations in temperature of the flow entering the hottest tubes in the steam generator





Update Steam Generator Flaw Distributions



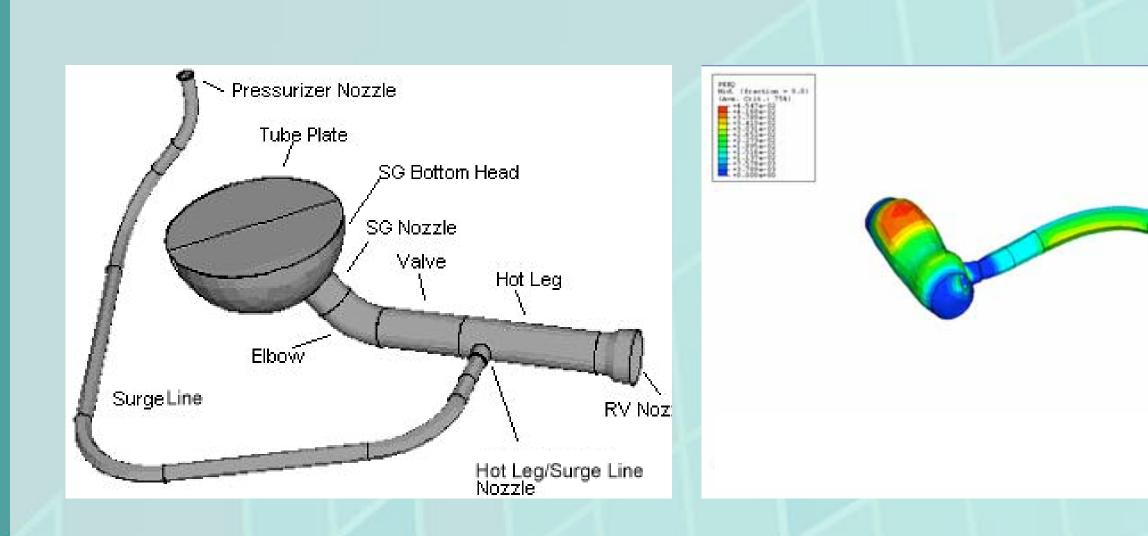
Obtain detailed knowledge of the characteristics of the flaws in the tube to enable realistic estimates of the probability of tube rupture.

Develop representative flaw distributions.

Verify the consistency of the flaw distributions with operating experience data for observed leakage rates.

Finite Element Analyses

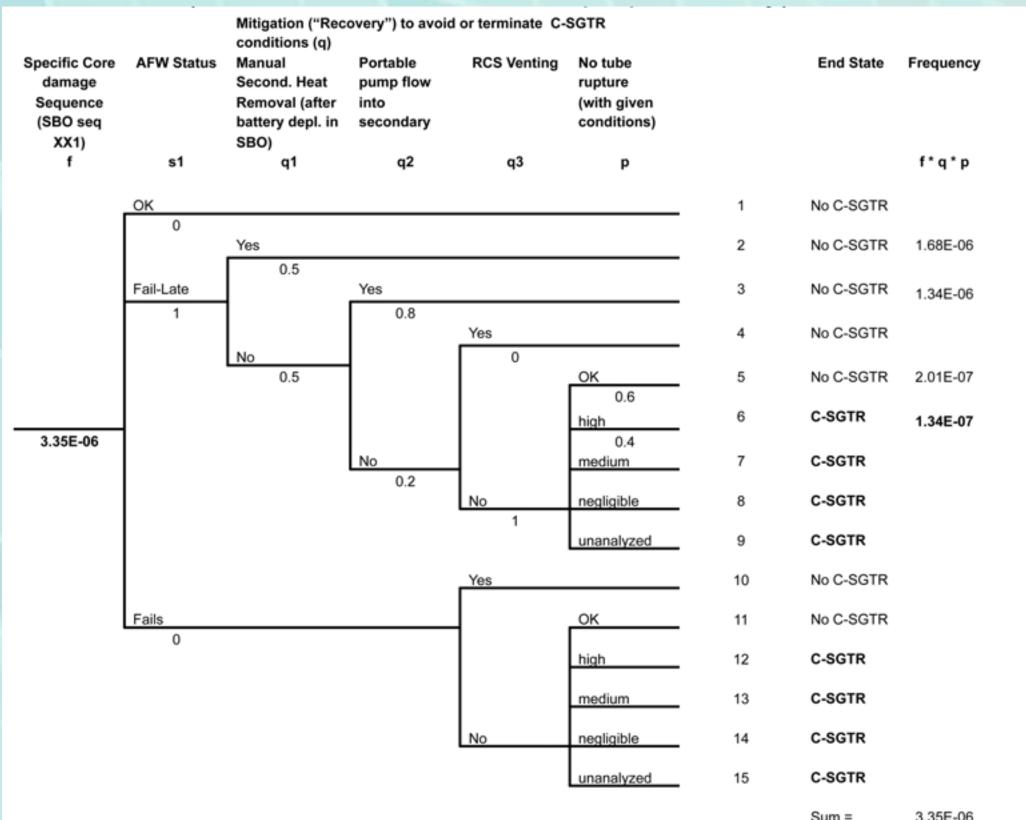
Prediction of RCS Component Failure Time



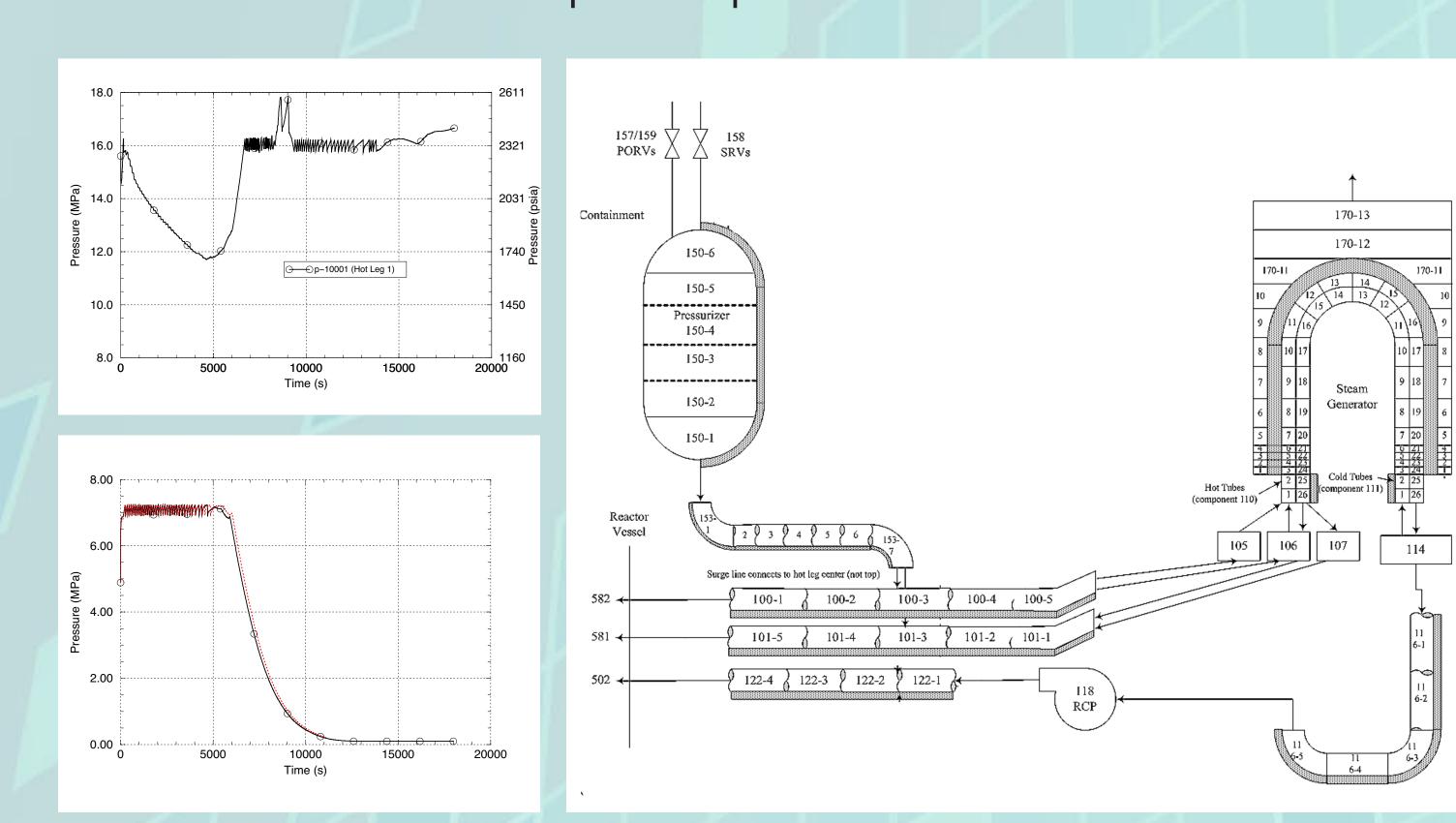
An Illustration of Factors Considered for Estimating C-SGTR Frequency Given a Core Damage Sequence (numbers are for illustration purposes only) Mitigation ("Recovery") to avoid or terminate C-SGTR

Event Trees Are Used To Assess Risk

C-SGTR Release Category Definitions



Calculation of Overall System Response with MELCOR Predictions of the transient plant response to severe accident scenarios



Previous SCDAP/RELAP Calculations—NUREG/CR-6995, "SCDAP/RELAP5
Thermal-Hydraulic Evaluations of the Potential for Containment Bypass
During Extended Station Blackout Severe Accident Sequences in a
Westinghouse Four-Loop PWR," March 2010

Research Products

Simplified Method To Assess Risk Associated with Consequential Tube Rupture and a Summary Report

Draft Regulatory Guidance on Risk-Informed Decision Making

Draft RASP Handbook Section on Assessment of C-SGTR (suitable to support revisions to the Appendices to Inspection Manual Chapter 0609, "Significance Determination Process" supporting the Significance Determination Process (SDP))